MEMORANDUM

TO: Glenn Curtis, Project Manager

FROM: Hieu Vu, Region 7 TATM

THRU: Joe Chandler, Region 7 TATL

DATE: February 24, 1989

SUBJECT: Analysis of Spring River Fish and Sediment for Five Year Sampling Period (1984 - 1988)

Per our conversation on February 3, 1989, you requested a partial draft report of the above subject for the near future meeting between EPA and Syntex representatives. Please find attached a copy of the draft results of the fish statistical evaluation. The sediment statistical evaluation was not included due to the lack of represented data (two out of eighteen samples were detected over a period of five years at three different locations).

The complete final report of the above subject, which follows our previously discussed format will be submitted to you the first week of March, 1989. Should you have any questions, please contact our office.

HV:pjk

Attachment

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I. INTRODUCTION

Between 1968 and 1969 the herbicide 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) was manufactured for the military at a chemical company located adjacent to the Spring River area in Verona, Missouri. Between 1969 and 1972, the facility produced hexachlorophene, using 2,4,5-Trichlorophenol as an intermediate. In both herbicide and hexachlorophenol production, 2,3,7,8-tetrachlorodibenso - p - dioxin was formed as a contaminant. The distillation residues (containing TCDD) from hexachlorophene production was disposed of at several locations in southwestern Missouri, resulting in several uncontrolled hazardous waste sites. Distillation residues were also used by some farmers along the Spring River because it was thought the residue would prevent hoof rot in cattle. The Spring River supports one of the major sport fisheries in southern Missouri. Because of the proximity of the chemical manufacturing company and hazardous waste disposal sites to the Spring River, the Environmental Protection Agency (EPA) developed a comprehensive dioxin monitoring program to detect the presence of dioxin in the Missouri Spring River Basin.

On November 16, 1981, the EPA Region VII collected fish and sediment samples from the Spring River for 2,3,7,8-TCDD analysis. The results of this effort confirmed the presence of 2,3,7,8-TCDD in fish tissues. Subsequent sampling has been conducted in December 1981, August 1982, December 1983 and August 1984.

On September 6, 1983, Syntex Agribusiness, Inc. entered into an Administrative Order with the EPA. Under this agreement, Syntex was to develop a fish and sediment monitoring plan for the Spring River in the vicinity of their Verona, Missouri facility. The "Verona Plant Fish and Sediment Plan" was accepted by the EPA on March 9, 1984. Under this order, the fish and sediment plan shall provide, initially, for sampling and analysis of Spring River fish for a five (5) year period extending up to twelve (12) miles downstream from the facility (0.3, 3, 6, 9, 12 miles downstream from the facility). Such period and/or distance may be extended or shortened by mutual agreement based on the results obtained. Therefore, the effort of this draft report is to analyze fish and sediment data from the Spring River for the period 1984 to late 1988 to determine if there is (1) no statistically significant decrease in the fish results at the 0.3 mile location downstream from the confluence of the Slough area and the Spring River (0.3 mile location) or (2) a statistically significant aggregated increase in the fish results at all other sampling points.

II. DATA EVALUATION

All of the fish and sediment data from the five year sampling period are included in Table 1. Fish samples were collected every year from 1984 to 1988 at 5 different locations (0.3, 3, 6, 9, and 12 miles downstream from Syntex). Sediment samples were also collected every year from 1984 to 1988 at 3 different locations (0.3, 6, and 12 miles

downstream from Syntex). It is noticed that sediment samples showed 2 detected values out of 18 collected samples over a period of 5 years; thus, the statistical evaluation on Spring River sediment will not be analyzed in this report.

Since different fish species bioconcentrate dioxin at different rates, the proper selection of fish species used for monitoring dioxin levels in the aquatic environment is essential when determining the degree and extent of TCDD contamination. In addition, significant errors in fish statistical analysis may arise from the effects of bioconcentration, bioaccumulation, and biomagnification factor as well as from the discrepancy of laboratory analytical methods. Therefore, these affected factors were taken into consideration in the evaluation of fish study.

A. Bioconcentration Factor:

Factors affecting dioxin bioconcentration in fish are metabolism and fat content. Generally, fish with high fat content bioconcentrate TCDD to higher levels (Bache et al, 1972). In addition, it is also important to sample fish for environmental contaminants during the same time period each year because contaminant levels in fish fluctuate on a seasonal basis, particularly when fish are spawning (Wilfred 1982). When spawning, fish should contain the highest TCDD levels since TCDD lipophilic and fish build up a large body of reproductive materials high in fats. Therefore, sampling fish during this time period will provide data on maximum TCDD levels in fish.

Although spawning period of fish in the Spring River has not yet been studied to determine the season of which TCDD concentration in fish may be at a highest level, fish samples from the initial 5 year sampling period were collected in the same season each year from 1984 to 1988. The consistency in sampling time would minimize the fluctuation of contaminant levels in fish and that would lessen the variation of data efficiency in the analysis. In addition, the average weight of fish of each sample batch was evaluated from year to year at each location to determine the consistency of sample collection throughout the 5 year collection. The average sample weights of fish indicated slight differences from year to year, however, these variations may not be statistically significant to the evaluation since fillet samples were used in the analytical procedure instead of whole fish samples. The TCDD levels in the whole fish may be affected by the weight factor since these levels were calculated from the TCDD concentrations and weights of fillets, TCDD concentrations and weights of remainders, and total weights.

B. Bioaccumulation Factor:

Generally, older fish bioaccumulate TCDD to higher levels (Bache et al, 1972). One of the considerations to justify fish age is its length. The average length of fish of each sample batch was evaluated from year to year at each location to determine the consistency of

sample collection throughout the 5 year collection. The average sample lengths of fish indicated slight differences from year to year. These variations may indeed represent a different TCDD bioaccumulation levels in fish. In addition, fish feeding habits of different species, especially predators may accumulate TCDD to higher levels. However, in this evaluation bottom feeders were chosen for the analysis rather than predators; the effect can be neglected.

C. Biomagnification Factor:

Generally higher tropic levels of fish may accumulate to higher TCDD levels. This effect can be neglected since fish samples were collected within the 12 mile distance of the study area in Spring River.

D. Laboratory Analytical Procedures:

All the fish data were generated in compliance with the Fish and Sediment Plan. The 1984 and 1985 analyses were performed by Dr. Gross at the University of Nebraska, Lincoln. However, the 1986, 1987, and 1988 analyses were performed by the Syntex Research laboratory. Although fish analyses were performed by two different laboratories, the analytical procedure was based on the methodology which was developed and validated and used by Dr. Gross from the analyses of 1984 and 1985 data. This method (No.10,349), Determination of 2,3,7,8,-TCDD in Fish by Capillary Gas Chromatography High Resolution Mass Spectrometry Selected Ion Monitoring (C-GC/HRMS-SIM) were used by the Midwest Center for Mass Spectrometry (University of Nebraska). Validation of the method was performed using samples of fish which had been assayed by the Midwest Center for Mass Spectrometry. These samples were reanalyzed by Syntex Research using Method 10,349 utilizing the frozen homogenates retained from Dr. Gross' analyses. The agreement between the analyses by the two laboratories is within the expected range of replicate analyses. Therefore, even though analyses were performed by two different laboratories, their results were compatible and can be incorporated into the evaluation with a few degrees of variation.

III. ANALYTICAL PROCEDURE AND STATISTICAL ANALYSIS

The analytical procedure for fish samples was performed according to the methodology mentioned above.

The data to be statistically analyzed will consist, initially, of two independent TCDD measurements ("Data Points") at each of five locations at each of five time points one year apart. Each Data Point will be the result of an analysis of a homogenate of the fillets from four to ten fish. If less than eight fish are obtained from any location, a single homogenate will be prepared an analyzed. A value of one-half the detection limit of the assay will be assigned to all samples which fall below the detection limit. Any analysis having a detection limit above 15 ppt will be repeated, if practicable, or removed from the statistical analysis of the data.

The 1984 whole fish data were calculated based on the assumption that fillet portion was 15% of body weight since the necessary weight information for calculation of whole fish TCDD concentration was not available, according to a memorandum from Syntex Research to the Missouri Department of Conservation Fish and Wildlife Research Center.

IV. EVALUATION RESULTS

Results of the Spring River fish statistical analysis over a 5 year sampling period were included in Table 2 to Table 15. Data were plotted using linear least square method and Student's t distribution was applied to each data plot to determine the significant figures of the slope and intercept values using 95% confidence limits. In addition, a value of correlation coefficient (r) was obtained from each curve to determine the efficiency of data for analysis interpretation. The value of r is between -1 and 1. If r equals -1 or 1, all data points on the correlation diagram are on the line. The further the value of r is from -1 and 1, the less the points mass about the line and the less reliable is the correlation.

A. Fish Statistical Analysis at Location 1 (0.3 miles downstream) - Table 2

Fish fillet statistical analysis at location 1 over a 5 year sampling period indicated a slight increase TCDD concentration in fish with respect to time. Its slope has a value of 0.0024. However, the correlation coefficient of the data point was so small (0.0149) which indicated a statistical inefficient data source to interpret the analysis of this particular purpose. In addition, the Student's t application showed a large variation of the slope value (0.0024+ - 0.0397) which indicated a less reliable data source to statistically justify neither an increase nor decrease of TCDD concentration in fish with respect to time at location 1.

Whole fish statistical analysis at location 1 over a 5 year sampling period indicated a higher increase of TCDD concentration in fish with respect to time than that of fish fillet. Its slope has a value of 0.0474 compared to that of fillet which has a slope value of 0.0024. However, the r-value of the data points was so small (0.1542) which indicated an inefficient data source to interpret the analysis of this particular purpose. In addition, the Student's t application showed a large variation of the slope value (0.0474+ - 0.1824).

B. Fish Statistical Analysis at Aggregated Locations (3, 6, 9, 12 miles downstream) - Table 3

Fish fillet statistical analysis at aggregated locations (3, 6, 9, 12 miles downstream) using average values indicated a slight increase of TCDD concentration in fish with respect to time. Its slope has a value of 0.0095. However, the r-value of the data points was so small (0.0597) which indicated a statistical inefficient data source to interpret the analysis of this particular purpose. In addition, the

Student's t application on the fish fillet slope showed a large variation (0.0095+ - 0.0698). The r-value and Student's t application indicated that the data source was less reliable to statistically justify neither an increase nor decrease of TCDD concentration in fish with respect to time at aggregated locations.

Whole fish statistical analysis at aggregated locations over the 5 year sampling period indicating a higher increase of TCDD concentration in fish with respect to time than that of fish fillet. Its slope has a value of 0.0132 compared to that of fillet which has a slope value of 0.0095. However, the r-value obtained from the plot and Student's t application on the whole fish slope indicated a large variation which indicated a less reliable data source to interpret the fish analysis of this particular purpose.

C. Fish Statistical Analysis - Concentration Versus Time At The Study Area (0.3, 4, 6, 9, 12 miles downstream) - Table 4 to Table 9.

Fish fillet statistical analysis was conducted at each sampling location over a 5 year sampling period to determine if any TCDD contamination trend in fish with respect to time. In general, the evaluations indicated slight increases in TCDD concentrations in fish with respect to time at location 1 and location 2. The TCDD levels in fish at locations 3, 4 and 5 showed mild decreases with respect to time. However, the r-values obtained from the plots were relatively small which indicated inefficient data sources for the fish analyses of this particular purpose. Of those 5 r-values, the r-value obtained from the location 2 plot showed relatively higher value than others.

The fish fillet evaluation at location 2 revealed a slight increase in fish TCDD levels over a 5 year sampling period (slope = 0.0903). The r-value obtained from this plot was 0.5507. In addition, the Student's t application on the location 2 slope showed relatively smaller variation than that at other locations. In other words, the combining of r-value and Student's t application indicated that the data source at location 2 was statistically significant than data source at other locations, thus, the fish data at this location was more reliable and can be used in the fish analysis of this particular purpose.

Whole fish statistical analysis was conducted at each sampling location over a 5 year sampling period to determine if any TCDD contamination trend in fish with respect to time. In general the evaluations indicated slight increases in TCDD concentration in fish at all locations but location 3. However, r-values obtained from the plots were small and Student's t applications on the above slopes showed large variations which indicated less reliable data sources for the fish analyses of this particular purpose.

In summary, the fish statistical analyses of TCDD concentration versus time at the entire study area over a 5 year sampling period are included in Table 9. The whole fish TCDD levels were higher than that of fish fillet. The whole fish slope has a value of 0.0253 compared to

that of fish fillet which has a slope of 0.0053. Furthermore, the whole fish r-value was much higher than that of fish fillet, which indicated a more correlated data than that of fillet. This could probably be due to the contribution of the whole fish weight since whole fish TCDD concentration was calculated based on its weight. However, both r-values obtained from the 2 plots (whole fish and fillet) were relatively small (0.1122 and 0.0408) in addition to large variations of the slope values. Therefore, neither the whole fish data nor fillet data can be used to either statistically justify an increase or decrease of TCDD concentration levels in fish with respect to time over the entire study area.

D. Fish Statistical Analysis. Concentration Versus Distance Over A 5 Year Sampling Period (1984 - 1988) - Table 10 to Table 15

Fish fillet statistical analysis was conducted each year from 1985 to 1988 over the entire study area to determine if any TCDD contamination trend in fish with respect to distance. In general, the evaluations indicated significant decreases in TCDD concentrations in fish with respect to distance every year from 1984 to 1988. The r-values obtained from the plots were very close to -1 (-0.7225 in 1986 to -0.9591 in 1987) which indicated statistically significant data sources for the fish statistical analyses of this particular purpose. In addition, Student's t application on the slopes showed small variational degrees (-01384+ - 0.0635 in 1984; -0.2071+ - 0.0515 in 1985; -0.0831+ - 0.0002 in 1986; -0.2220+ - 0.0737 in 1987; and -0.1972+ - 0.0470 in 1988), thus, more reliable data sources for the particular analyses.

Whole fish statistical analyses of the entire study area showed significant decreases in TCDD concentrations in fish with respect to distance every year from 1984 to 1988. The r-values obtained from the plots were very close to -1 (-0.7888 in 1986 to -0.9281 in 1984), which indicated statistically significant data sources for the fish statistical analyses of the particular purpose. In addition, Student's t application on the slopes showed small variational degrees (-0.1796+ - 0.0688 in 1984; -0.2243+ - 0.1187 in 1985; -0.1378+ - 0.0901 in 1986; -0/1885+ - 0.0787 in 1987; and -0.1654+ - 0.0491 in 1988), thus, more reliable data sources for the particular analyses.

In summary, the fish statistical analyses of TCDD concentration versus distance over the 5 year sampling period are included in Table 15. Both whole fish and fish fillet evaluations showed significant decreases in TCDD concentration levels in fish with respect to distance over the entire 5 year sampling period. The r-values for whole fish and fish fillet were -0.9183 and -0.9439, respectively. In addition, Student's t application on the slopes (whole fish and fillet) showed small variational degrees (-0.1753+ - 0.0704 of whole fish and -0.1574+ - 0.0332 of fillet). The r-values and Student's t application on the slopes indicated that the data sources for this particular analyses were significantly reliable.

V. CONCLUSION AND RECOMMENDATION

TCDD-absorbed particulates in soil runoff accumulate in the sediments of water-courses, which then become the ultimate sinks. Therefore, sediment material becomes an effective and easily accessible monitoring tool for TCDD. Sediment material may also provide information about unknown TCDD sources as well as facilitate identification of contamination from known sites, since contaminants in sediment, unlike fish, cannot move upstream. Although the sediment sampling efforts by the EPA through the 5 year sampling period indicated that there were only two samples showing positive dioxin contamination of levels, 1.6 and 6.4 ppt (refer to Table 1), the rest of the sampling efforts from 1984 to 1988 were not detected.

The analysis of stream sediments for TCDD appears to be a viable tool for determining the extent and distribution of TCDD contamination within the drainage area of the TCDD site. However, the problem of sediment relocations may confound the identification of the source of contamination. Wakeham and Farington (1980) reported that pollutant hydrocarbons may be transported great distances from the source of contamination and deposited in sediments of remote areas. In addition, the upper reaches of the Spring River are subject to flooding on a fairly regular basis. The first USGS gauging station on the Spring River is at LaRussell, Missouri, 33 miles downstream from Verona. Average annual daily flow rate at this station is 252 cubic feet per second (cfs). Minimum and maximum flow rates for the period of record (1947 to present) are 15,000 and 22,500 cfs, respectively. Thus, while sediment samples may be the best method for identifying and mapping contamination, there are other factors that must be considered when using this parameter for monitoring purposes. The sediment statistical analysis was not analyzed due to the lack of represented data.

Fish study over the 5 year sampling period indicated that very limited conclusions can be made regarding the extent of migration. Suckers (bottom feeders) may travel 20 to 30 miles, and this would not be unusual for Bass. Also, fish can be expected to move upstream during the spring to spawn. Concentrations of environmental contaminates in fish can be expected to increase during the spring and summer when they are the fattest. All fish samples were collected in the same season (August) each year from 1984 to 1988, thus, minimizing the fluctuations of TCDD concentrations in fish, in terms of sample collection consistency.

Variables affected the fish statistical analysis for the Spring River over the 5 year sampling period were taken into the considerations of the evaluation and that led to the following conclusions:

- Fish data was analyzed by two different laboratories. University of Nebraska from 1984 to 1985 and Syntex Research Laboratory from 1986 to 1988. However, the two laboratories performed the same analylitcal procedures and their results were statistically compatible.

- Bioconcentration and bioaccumulation factors were taken into consideration which average fish weights and lengths were compared from year to year to determine the sample collection consistency. Average fish weight was slightly different from year to year, however, the fish evaluation might not be statistically significant since fillet samples were used for the laboratory analyses. Average fish lengths were slightly different from year to year and the differences might have affected the sample collection consistency, thus affecting the results of the fish evaluation.

The fish statistical analysis was performed according to the Verona Plant Fish and Sediment Plan and findings are included as follows:

- Fish data used to perform the statistical analysis at location 1 (0.3 miles downstream from Syntex) could not statistically determine either an increase or decrease of TCDD concentration in fish with respect to time over the 5 year sampling period (1984 - 1988).

- Fish data used to perform the statistical analysis at the aggregated locations (3, 6, 9, 12 miles downstream from Syntex) could not statistically determine either an increase or decrease of TCDD concentration in fish with respect to time over the 5 year sampling period (1984 - 1988).

In an effort to learn the extent of dioxin contamination on the Spring River, fish TCDD data were used to perform the statistical analyses of dioxin concentration versus time and distance, respectively, over the 5 year samplng period and the entire study area. The evaluation led to the following conclusions:

- Fish data used to perform the statistical analysis at the entire study area over the 5 year sampling period could not statistically determine either an increase or decrease of TCDD concentration in fish with respect to time over the 5 year sampling period (1984 - 1988).

- Fish data used to perform the statistical analysis at the entire study area over the 5 year sampling period statistically indicated a significant decrease of TCDD concentration in fish with respect to distance within the 12 miles downstream from Syntex.

In summary, results of the fish statistical analyses, despite all variational effects, indicated that fish in the Spring River have been exposed or are still exposed to the dioxin contaminant. In addition, the TCDD concentration in fish did not statistically show contamination correlation with respect to time, however, significantly showed the contamination correlation with respect to distance.

This lead to the conclusion that during the transportation of contaminated sediment to downstream areas, a slow but steady dissolution of TCDD into water and/or dilution of TCDD in large areas, thus fish futher away from the contamination point source are exposed to lower contamination levels.

Based on the above results, futher fish sampling and analysis is recommended for the Spring River fish study. The TCDD concentrations in both fish fillet and whole fish were significantly increased during 1986 to 1988 at both location 1 and aggregated locations (refer to Table 2 and Table 3). Therefore, it is recommended fish monitoring at the Spring River be conducted for at least 2 more years. These sampling effots should follow the sampling protocols which were described in the Verona Plant Fish and Sediment Plan. The next two year fish data will be incorporated into the Spring River five year fish statistical analysis from 1986 to 1990. In addition, the Spring River supports one of the major sport fisheries in southern Missouri and fish samples indicated elevations of TCDD concentrations in recent years. Therefore, a fish monitoring plan at the Spring River is still warranted to assure the contamination levels in fish not exceed the health standards in order to protect the public health and welfare.

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TABLE 1

FISH (SUCKER TYPE) AND SEDIMENT SAMPLES TAKEN FROM THE SPRING RIVER

SEDIMENT SAMPLES (ppt)

Location	1984	1985	1986	1987	1988 Feb.	1988 Sept.
Location No. 1 0.3 Miles Downstream	1.6	ND (3.0)	ND (7.5)	6.4	ND (13)	ND (13)
Location No. 3 6.0 Miles Downstream	ND (1.5)	ND (2.3)	ND (2.6)	ND (0.8)	ND (10)	ND (6)
Location No. 5 12.0 Miles Downstream	ND (1.2)	ND (2.5)	ND (9.1)	ND (0.8)	ND (1)	ND (1)

FISH SAMPLES (ppt)

Location	Sample Type	1984	1985	1986	1987	1988
Location No. 1	Whole fish	26	14	8.5	21.3	26.7
0.3 Miles Downstream	Fillet	4	3.0	2.5	4.8	3.2
Location No. 2	Whole fish	22-34	11	16.9	13.4	26.3
3.0 Miles Downstream	Fillet	4	3.0	4.4	3.4	5.9
Location No. 3	Whole fish	12	6.0	6.2	7.0	8.4
6.0 Miles Downstream	Fillet	3	ND (1.5)	1.3	1.8	1.3
Location No. 4	Whole fish	11	5.4	6.9	8.3	12.0
9.0 Miles Downstream	Fillet	2	1	1.7	1.3	1.2
Location No. 5	Whole fish	3	ND (1.5)	1.8	1.7	3.5
12.0 Miles Downstream	Fillet	ND (1.5)	ND (0.5)	1.2	0.3	0.4

ND None Detected

( ) Detection Limit

The 1984 and 1985 data was generated in compliance with the Fish and Sediment Plan and the analyses were performed by Dr. Gross at the University of Nebraska-Lincoln.

The 1986, 1987 and 1988 data was generated in compliance with the Fish and Sediment and the analyses were performed at Syntex Research Laboratory in Palo Alto, California.

Table 2

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FISH STATISTICAL ANALYSIS AT LOCATION 1 (0.3 MILES DOWNSTREAM)
****

Sample Type	1984	1985	1986	1987	1988
**********	****	****	****	****	****
Whole Fish	26.0	14.0	8.5	21.3	26.7
Fillet	4.0	3.0	2.5	4.8	3.2

Whole fish curve: Ln(conc.) = 0.0474 T + 2.7340

Correlation Coefficient: 0.1542

Slope variation (95% confidence limits): 0.1824

Intercept variation (95% confidence limits): 0.6050

Fish fillet curve: Ln(conc.) = 0.0024 T + 1.2194

Correlation Coefficient: 0.0149

Slope variation (95% confidence limits): 0.0397

Intercept variation (95% confidence limits): 0.1318

Concetration is in part-per-trillion (ppt)

T is year number (i.e., 1 for 1984, 2 for 1985, ect.)

Table 3

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FISH STATISTICAL ANALYSIS AT AGGREGATED LOCATIONS (2,3,4,5)
****

Sample Type	1984	1985	1986	1987	1988
**********	****	****	****	****	****
Whole Fish	13.5	5.8	8.0	7.6	12.6
Fillet	2.4	1.3	2.2	1.7	2.2

Whole fish curve: Ln(conc.) = 0.0132 T + 2.1608

Correlation Coefficient: 0.0582

Slope variation (95% confidence limits): 0.1785

Intercept variation (95% confidence limits): 0.5919

Fish fillet curve: Ln(conc.) = 0.0095 T + 0.6203

Correlation Coefficient: 0.0597

Slope variation (95% confidence limits): 0.0698

Intercept variation (95% confidence limits): 0.2316

Concetration is in part-per-trillion (ppt)

T is year number (i.e., 1 for 1984, 2 for 1985, ect.)

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Table 4

FISH STATISTICAL ANALYSIS - CONCENTRATION VERSUS TIME (LOCATION 1)

Sample Type	1984	1985	1986	1987	1988
**********	****	****	****	****	****
Whole Fish	26.0	14.0	8.5	21.3	26.7
Fillet	4.0	3.0	2.5	4.8	3.2

Whole fish curve: Ln(conc.) = 0.0474 T + 2.7340

Correlation Coefficient: 0.1542

Slope variation (95% confidence limits): 0.1824

Intercept variation (95% confidence limits): 0.6050

Fish fillet curve: Ln(conc.) = 0.0024 T + 1.2194

Correlation Coefficient: 0.0149

Slope variation (95% confidence limits): 0.0397

Intercept variation (95% confidence limits): 0.1318

Concetration is in part-per-trillion (ppt)

T is year number (i.e., 1 for 1984, 2 for 1985, ect.)

Table 5

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FISH STATISTICAL ANALYSIS - CONCENTRATION VERSUS TIME (LOCATION 2)

Sample Type	1984	1985	1986	1987	1988
**********	****	****	****	****	****
Whole Fish	28.0	11.0	16.9	13.4	26.3
Fillet	4.0	3.0	4.4	3.4	5.9

Whole fish curve: Ln(conc.) = 0.0073 T + 2.8625

Correlation Coefficient: 0.0281

Slope variation (95% confidence limits): 0.2155

Intercept variation (95% confidence limits): 0.7148

Fish fillet curve: Ln(conc.) = 0.0903 T + 1.1223

Correlation Coefficient: 0.5507

Slope variation (95% confidence limits): 0.1169

Intercept variation (95% confidence limits): 0.3877

Concetration is in part-per-trillion (ppt)

T is year number (i.e., 1 for 1984, 2 for 1985, ect.)

Table 6

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FISH STATISTICAL ANALYSIS - CONCENTRATION VERSUS TIME (LOCATION 3)

Sample Type	1984	1985	1986	1987	1988
**********	****	****	****	****	****
Whole Fish	12.0	6.0	6.2	7.0	8.4
Fillet	3.0	0.8	1.3	1.8	1.3

Whole fish curve: Ln(conc.) = -0.0560 T + 2.2032

Correlation Coefficient: -0.3120

Slope variation (95% confidence limits): 0.1190

Intercept variation (95% confidence limits): 0.3946

Fish fillet curve: Ln(conc.) = -0.0798 T + 0.6240

Correlation Coefficient: -0.2481

Slope variation (95% confidence limits): 0.0215

Intercept variation (95% confidence limits): 0.0713

Concetration is in part-per-trillion (ppt)

T is year number (i.e., 1 for 1984, 2 for 1985, ect.)

Table 7

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FISH STATISTICAL ANALYSIS - CONCENTRATION VERSUS TIME (LOCATION 4)

Sample Type	1984	1985	1986	1987	1988
**********	****	****	****	****	****
Whole Fish	11.0	5.4	6.9	8.3	12.0
Fillet	2.0	1.0	1.7	1.3	1.2

Whole fish curve: Ln(conc.) = 0.0604 T + 1.9422

Correlation Coefficient: 0.2899

Slope variation (95% confidence limits): 0.1399

Intercept variation (95% confidence limits): 0.4640

Fish fillet curve: Ln(conc.) = -0.0760 T + 0.5616

Correlation Coefficient: -0.4334

Slope variation (95% confidence limits): 0.0002

Intercept variation (95% confidence limits): 0.0008

Concetration is in part-per-trillion (ppt)

T is year number (i.e., 1 for 1984, 2 for 1985, 'ect.)

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Table 8

FISH STATISTICAL ANALYSIS - CONCENTRATION VERSUS TIME (LOCATION 5)

Sample Type	1984	1985	1986	1987	1988
**********	****	****	****	****	****
Whole Fish	3.0	0.8	1.8	1.7	3.5
Fillet	0.8	0.3	1.2	0.3	0.4

Whole fish curve: Ln(conc.) = 0.1127 T + 0.2985

Correlation Coefficient: 0.2947

Slope variation (95% confidence limits): 0.2272

Intercept variation (95% confidence limits): 0.7534

Fish fillet curve: Ln(conc.) = -0.1074 T + -0.4002

Correlation Coefficient: -0.2592

Slope variation (95% confidence limits): 0.0123

Intercept variation (95% confidence limits): 0.0408

Concetration is in part-per-trillion (ppt)

T is year number (i.e., 1 for 1984, 2 for 1985, ect.)

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Table 9

FISH STATISTICAL ANALYSIS - CONCENTRATION VERSUS TIME
****

Sample Type	1984	1985	1986	1987	1988
**********	****	****	****	****	****
Whole Fish	16.0	7.4	8.1	10.3	15.4
Fillet	2.8	1.6	2.2	2.3	2.4

Whole fish curve: Ln(conc.) = 0.0253 T + 2.3105

Correlation Coefficient: 0.1122

Slope variation (95% confidence limits): 0.1725

Intercept variation (95% confidence limits): 0.5723

Fish fillet curve: Ln(conc.) = 0.0053 T + 0.7833

Correlation Coefficient: 0.0408

Slope variation (95% confidence limits): 0.0379

Intercept variation (95% confidence limits): 0.1256

Concetration is in part-per-trillion (ppt)

T is year number (i.e., 1 for 1984, 2 for 1985, ect.)

Table 10

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FISH STATISTICAL ANALYSIS - CONCENTRATION VERSUS DISTANCE (1984)

Sample Type	0.3	3.0	6.0	9.0	12.0
**********	****	****	****	****	****
Whole Fish	26.0	28.0	12.0	11.0	3.0
Fillet	4.0	4.0	3.0	2.0	0.8

Whole fish curve: Ln(conc.) = -0.1796 X + 3.6030

Correlation Coefficient: -0.9281

Slope variation (95% confidence limits): 0.0688

Intercept variation (95% confidence limits): 0.5059

Fish fillet curve: Ln(conc.) = -0.1384 X + 1.6936

Correlation Coefficient: -0.9199

Slope variation (95% confidence limits): 0.0635

Intercept variation (95% confidence limits): 0.4666

Concetration is in part-per-trillion (ppt)

X is number miles downstream from Syntex

Table 11

DRAFT

FISH STATISTICAL ANALYSIS - CONCENTRATION VERSUS DISTANCE (1985)
****

Sample Type	0.3	3.0	6.0	9.0	12.0
**********	****	****	****	****	****
Whole Fish	14.0	11.0	6.0	5.4	0.8
Fillet	3.0	3.0	0.8	1.0	0.3

Whole fish curve: Ln(conc.) = -0.2243 X + 3.0050

Correlation Coefficient: -0.9049

Slope variation (95% confidence limits): 0.1187

Intercept variation (95% confidence limits): 0.8723

Fish fillet curve: Ln(conc.) = -0.2071 X + 1.3599

Correlation Coefficient: -0.9218

Slope variation (95% confidence limits): 0.0515

Intercept variation (95% confidence limits): 0.3784

Concetration is in part-per-trillion (ppt)

X is number miles downstream from Syntex

Table 12

DRAFT

FISH STATISTICAL ANALYSIS - CONCENTRATION VERSUS DISTANCE (1986)

Sample Type	0.3	3.0	6.0	9.0	12.0
**********	****	****	****	****	****
Whole Fish	8.5	16.9	6.2	6.9	1.8
Fillet	2.5	4.4	1.3	1.7	1.2

Whole fish curve: Ln(conc.) = -0.1378 X + 2.6973

Correlation Coefficient: -0.7888

Slope variation (95% confidence limits): 0.0901

Intercept variation (95% confidence limits): 0.6621

Fish fillet curve: Ln(conc.) = -0.0831 X + 1.1781

Correlation Coefficient: -0.7225

Slope variation (95% confidence limits): 0.0002

Intercept variation (95% confidence limits): 0.0013

Concetration is in part-per-trillion (ppt)

X is number miles downstream from Syntex

Table 13

DRAFT

FISH STATISTICAL ANALYSIS - CONCENTRATION VERSUS DISTANCE (1987)

****

Sample Type	0.3	3.0	6.0	9.0	12.0
**********	****	****	****	****	****
Whole Fish	21.3	13.4	7.0	8.3	1.7
Fillet	4.8	3.4	1.8	1.3	0.3

Whole fish curve: Ln(conc.) = -0.1885 X + 3.1919

Correlation Coefficient: -0.9192

Slope variation (95% confidence limits): 0.0787

Intercept variation (95% confidence limits): 0.5787

Fish fillet curve: Ln(conc.) = -0.2220 X + 1.8333

Correlation Coefficient: -0.9591

Slope variation (95% confidence limits): 0.0737

Intercept variation (95% confidence limits): 0.5415

Concetration is in part-per-trillion (ppt)

X is number miles downstream from Syntex

Table 14

DRAFT

FISH STATISTICAL ANALYSIS - CONCENTRATION VERSUS DISTANCE (1988)

Sample Type	0.3	3.0	6.0	9.0	12.0
**********	****	****	****	****	****
Whole Fish	26.7	26.3	8.4	12.0	3.5
Fillet	3.2	5.9	1.3	1.2	0.4

Whole fish curve: Ln(conc.) = -0.1654 X + 3.4868

Correlation Coefficient: -0.9032

Slope variation (95% confidence limits): 0.0491

Intercept variation (95% confidence limits): 0.3607

Fish fillet curve: Ln(conc.) = -0.1972 X + 1.6882

Correlation Coefficient: -0.8918

Slope variation (95% confidence limits): 0.0470

Intercept variation (95% confidence limits): 0.3454

Concetration is in part-per-trillion (ppt)

X is number miles downstream from Syntex

Table 15

DRAFT

FISH STATISTICAL ANALYSIS - CONCENTRATION VERSUS DISTANCE
****

Sample Type	0.3	3.0	6.0	9.0	12.0
**********	****	****	****	****	****
Whole Fish	19.3	19.1	7.9	8.7	2.2
Fillet	3.5	4.1	1.6	1.4	0.6

Whole fish curve: Ln(conc.) = -0.1753 X + 3.2481

Correlation Coefficient: -0.9183

Slope variation (95% confidence limits): 0.0704

Intercept variation (95% confidence limits): 0.5172

Fish fillet curve: Ln(conc.) = -0.1574 X + 1.5456

Correlation Coefficient: -0.9439

Slope variation (95% confidence limits): 0.0332

Intercept variation (95% confidence limits): 0.2437

Concetration is in part-per-trillion (ppt)

X is number miles downstream from Syntex